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Effect of phosphorus, sulphur and biofertilizer on yield and quality of greengram (*Vigna radiata* L. Wilczek) in loamy sand under Dryland condition

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Abstract
The experiment was conducted during the *Kharif* season of the year 2018 at AICRP for Dry Land, Centre for natural resources management, Sadarkrushinagar datiwada agricultural university, Sardarkrushinagr, Gujarat. The results revealed that integrated application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB registered significantly higher growth, yield attributes, seed and stover yield as well as protein content of greengram. But it was found at par with treatments *viz.*, 40 kg P_2O_5/ha + 20 kg S and PSB, 30 kg P_2O_5/ha + 20 kg S/ha + PSB and 50 kg P_2O_5/ha + 20 kg S/ha. From these results, it could be concluded that for securing higher seed yield and net realization of greengram (cv. Gujarat Mungbean 4) raised on loamy sand under north Gujarat conditions, the crop should be fertilized with phosphorus @ 30 kg/ha, sulphur @ 20 kg/ha with PSB (phosphorus solubilizing bacteria) liquid biofertilizer along with recommended dose of N @ 20 kg/ha. By this way, 10 kg P_2O_5/ha can be saved than recommended dose of 40 kg P_2O_5/ha for greengram.

Keywords: Greengram, biofertilizer, growth, yield attributes, yield and quality

Introduction
Greengram (*Vigna radiata* L.) is commonly known as moong or golden gram. It belongs to family *Leguminosae*. The India is the largest producer and consumer of pulses. In India, *kharif* greengram occupies an area of about 40.70 lakh ha with a production of 19.01 lakh tonnes (DE and S, 2018-19) [3]. In Gujarat, *kharif* greengram occupies an area of about 63,000 ha with a production of 24,000 tonnes and the productivity is 381 kg/ha, respectively (DOA, 2018-19) [2]. Phosphorus is a second major nutrient for plants because of their high requirement. It is also involved in controlling key enzyme reaction and in the regulation of metabolic pathways (Theodorou and Plaxton, 1993) [17]. Since the concentration of phosphorus in the soil solution is normally insufficient to support plant growth, continual replacement of soluble phosphorus from inorganic and organic source is necessary for crop growth (Chauhan *et al*., 1997) [1]. So, to meet the phosphorus requirements of crops phosphatic fertilizer are used. Sulphur is essential for synthesis of vitamins (Biotin and Thiamine), sulphur containing amino acid that are cystine, cysteine and methionine is a requisite for protein synthesis. It is also constituent of glutathione, a compound that plays a part in plant respiration and synthesis of essential oils. It has a number of oxidizing functions in plant nutrition and a constituent of Fe-S proteins called Ferredoxin, responsible for transfer of electrons during the first phase of photosynthesis reaction (Petrovic and Kastori, 1994; Marchner, 1995; Goswami, 1988 and Randall, 1988) [7, 5, 12]. Seed inoculation with proper strain of phosphorus solubilizing bacteria is low cost input for enhancing yield, as it solubilize the unavailable phosphorus in to the available form, which reduces the high cost of inorganic phosphatic fertilizer (Parveen *et al*. 2002) [9]. Phosphorus dissolving microorganisms have capacity to render insoluble form of phosphate more available to plant besides, metabolic product of soil microbes such as organic acids and humic substances from complexes with Fe and Al compounds, thereby reducing further fixation.

Materials and Methods
A field experiment on "Effect of phosphorus, sulphur and biofertilizer on yield and quality of greengram (*Vigna radiata* L.) in loamy sand under dry land condition". The field experiment was laid out on Plot No. 9 at AICRP for Dry land Agriculture, Centre for Natural Resources

Management, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* season of 2017-18. North Gujarat has semi-arid and sub-tropical climate situated in 24° 19' North latitude 72° 19' East longitude and 154.52 meter above mean sea level. The soil of experimental field was loamy sand having high infiltration rate, poor water holding capacity, low in soil organic carbon (0.26 %), available nitrogen (137.40 %) and sulphur content (9.52), while medium in available phosphorus (37.40 %) and slightly alkaline in reaction. Total twelve treatments *viz.,* T_1 : 30 kg P_2O_5 ha^{-1}, T_2 : 40 kg P_2O_5 ha^{-1}, T_3 : 50 kg P_2O_5 ha^{-1}, T_4 : 30 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}, T_5 : 40 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}, T_6 : 50 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1}, T_7 : 30 kg P_2O_5 ha^{-1} + PSB, T_8 : 40 kg P_2O_5 ha^{-1} + PSB, T_9 : 50 kg P_2O_5 ha^{-1} + PSB, T_{10} : 30 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} + PSB, T_{11} : 40 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} + PSB and T_{12} : 50 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} + PSB were tried in randomized block design with three replications in loamy sand soil. The details of treatments tested in the present investigation on "Effect of phosphorus, sulphur and biofertilizer on yield and quality of greengram (*Vigna radiata* L.) In loamy sand under dry land condition.

The data collected from experiment at different crop growth stages on growth and yield attributes and yield, quality and chemical study were subjected to statistical analysis and interpretation of data of various characters studied in present investigation was done by Fisher's method of analysis of variance technique as suggested by Panse and Sukhatme (1985) [10]. The level of significance used in "F" test was P = 0.05, critical difference values were calculated whenever the "F" test was significant. In the remaining cases, only standard errors of mean were worked out. The co-efficient of variance percentage (C.V. %), illustration based on the data are given at appropriate places in respective table.

Results and Discussion

Growth and yield attributes

Plant population per meter row length at harvest

The data presented in table 1 exhibited that the plant population per meter row length at harvest did not differ significantly due to different treatments which indicated that there was no significant effect of different treatments on plant population at harvest. The non-significant results indicated that uniform plant population was maintained up to harvest. Thus, there was no effect of different treatments on plant population as well as on survival of plants.

Plant height

The data given in Table 1 and Fig. 1 revealed that plant height measured at harvest was significantly influenced due to different treatments. The plant height at harvest was varied from 40.39 to 47.79 cm. The data presented revealed that significantly the highest plant height (47.79 cm) was noted due to application of 50 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} + PSB over rest of treatments, but it was remained at par with treatments *viz.,* 40 kg P_2O_5/ha + 20 kg S and PSB, 30 kg P_2O_5/ha + 20 kg S/ha + PSB and 50 kg P_2O_5/ha + 20 kg S/ha. The treatments 30 kg P_2O_5/ha registered the lowest plant height of greengram. The increase in plant height due to combined use of P_2O_5, S and PSB in present study was might be due to improvement in vegetative structure for nutrient absorption and photosynthesis. Similar results were observed by Manju *et al*. (2012) and Saini *et al.* (2017) [13] in greengram.

Branches per plant

An appraisal of data given in Table 1.0 and fig.1 showed that the differences in the branches per plant at harvest due to different treatments were found significant. The results indicated that an application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB registered significantly higher branches per plant (9.40) over all other treatments, but it was found at par with treatments *viz*., 40 kg P_2O_5/ha + 20 kg S and PSB (8.86), 30 kg P_2O_5/ha + 20 kg S/ha + PSB (8.86) and 50 kg P_2O_5/ha + 20 kg S/ha (8.57). The lowest branches per plant were recorded under treatment 40 kg P_2O_5/ha (5.96). The increase in branches per plant was might be due to the increased supply of almost all plant essential nutrients which improved the overall growth and development of plant. These results are in accordance with those reported by Das (2017) [4], Singh *et al*. (2015) [15] and Singh *et al*. (2018) [16] in greengram.

Number of pods per plant and number of seeds per pod

The results indicated (table 1) and fig. 2.0 that application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB recorded significantly higher number of pods per plant (19.08) and number of seeds per pod (8.07) over rest of the treatments, but it was found at par with treatments *viz.,* 40 kg P_2O_5/ha + 20 kg S/ha + PSB, 30 kg P_2O_5/ha + 20 kg S/ha + PSB and 50 kg P_2O_5/ha + 20 kg S/ha. The beneficial effect of phosphorous, sulphur and PSB could be attributed to fact that PSB caused mobilization of the native nutrients to increase their availability to growing crops. These results are in agreement with the findings of Patel *et al*. (2013) [11] and Singh *et al.* (2018) [16] in greengram.

100-seed weight

The data recorded on 100-seed weight of greengram (table 2) was significantly influenced due to different treatments. An application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB registered significantly higher 100-seed weight (4.84 g) over all other treatments, but it was found at par with treatments of *viz.,* 40 kg P_2O_5/ha + 20 kg S/ha + PSB, 30 kg P_2O_5/ha + 20 kg S/ha + PSB, 50 kg P_2O_5/ha + 20 kg S/ha and 40 kg P_2O_5/ha + 20 kg S/ha the increase in 100-seed. The increase in the 100-seed weight could be due to its primary role in photosynthesis by way of rapid energy transfer and there by increased photosynthetic efficiency and thus, increased in total biomass production and translocation in plant parts. The results are in accordance with those reported by Kumar *et al*. (2012) [6] and Singh *et al*. (2018) [16] in greengram.

Yields of greengram

The data pertaining to seed and stover yield of greengram are presented in Table 2.0 and fig.3 showed that the treatment receiving 50 kg P_2O_5 ha^{-1} + 20 kg S ha^{-1} + PSB produced significantly higher seed (761 kg/ha) and stover yield (131kg/ha), but it was remained at par with all the treatments consisting of phosphorus, sulphur and biofertilizer treatments except T_1, T_2, T_3 and T_7 and T_1, T_2, T_9 and T_7 for seed and stover, respectively.

The yield improvement was higher when phosphorous applied along with sulphur and PSB. The significant increase in yield of greengram due to phosphorous, sulphur and PSB might be due to fact that phosphorus, sulphur and PSB had synergistic effect on greengram yields as phosphorus is known to play beneficial role in legume by promoting extensive root development and nodulation ensuring better nutritional

environment for growth and finally the yield. Sulphur also played important role in energy transformation activation of enzymes, carbohydrate metabolism and also due to inoculation with PSB, which increased available phosphorus and favored higher absorption and utilization of P and plant nutrients and ultimately positive resultant effect on growth and yield attributes, which led to increase in seed and stover yield. These results are in the line of those reported by Patel *et al*. (2013) [11], Manju *et al*. (2016) [8], Sipai *et al*. (2016), Das (2017) [4] and Serawat *et al*. (2018) [14].

Quality parameters

Protein content and protein yield

The data pertaining to protein content in seed and protein yield of greengram are given in Table 3.0 and depicted graphically in fig.4.0 revealed that the differences in protein content of greengram were found non-significant.

The data presented in table 3.0 showed that protein yield was significantly influenced due to application of 50 kg P_2O_5/ha + 20 kg S/ha + PSB (169 kg/ha) over rest of treatments, but it was found at par with the treatments of *viz.*, 40 kg P_2O_5/ha + 20 kg S/ha + PSB (163 kg/ha), 30 kg P_2O_5/ha + 20 kg S/ha + PSB (162 kg/ha), 50 kg P_2O_5/ha + 20 kg S/ha (153 kg/ha), 40 kg P_2O_5/ha + 20 kg S/ha (148 kg/ha) and 30 kg P_2O_5/ha + 20 kg S/ha (145 kg/ha). The lowest protein yield (101 kg/ha) was obtained under treatment receiving 30 kg P_2O_5/ha.

Increase in protein yield in seed might be due to phosphorus which promotes root growth and thus, increase the uptake of nitrogen, which has resulted in increased protein content. Increased availability of sulphur due to application of sulphur and thus nitrogen availability was increased due to synergistic effect between N and S. Sulphur also synthesized some sulphur containing amino acids like cystine, cysteine and methionine thus, resulting in increased synthesis of protein. Since protein content of seed is essentially a manifestation of nitrogen content, increased nitrogen content due to seed inoculation with PSB resulted in higher protein content because of the beneficial role of PSB in enhancing N content in seed. Due to this fact application of phosphorous, sulphur and PSB has increased protein content and protein yield. These results are in close agreement with those reported by Saini *et al.* (2017) [13] and Singh *et al.* (2018) [16] in greengram.

Table 1: Effect of phosphorus, sulphur and biofertilizer on plant height and branches per plant at harvest of *kharif* greengram

Treatments			Plant height (cm)	Branches per plant	Number of pods per plant	Number of seeds per pod
T_1	:	30 kg P_2O_5/ha	40.39	5.96	12.27	6.64
T_2	:	40 kg P_2O_5/ha	40.98	6.09	13.04	6.97
T_3	:	50 kg P_2O_5/ha	41.03	6.33	13.06	7.05
T_4	:	30 kg P_2O_5/ha + 20 kg S/ha	42.59	7.43	16.74	7.35
T_5	:	40 kg P_2O_5/ha + 20 kg S/ha	43.07	7.60	16.78	7.37
T_6	:	50 kg P_2O_5/ha + 20 kg S/ha	44.01	8.57	17.71	7.85
T_7	:	30 kg P_2O_5/ha + PSB	41.33	6.56	14.27	7.13
T_8	:	40 kg P_2O_5/ha + PSB	41.17	6.42	14.43	7.22
T_9	:	50 kg P_2O_5/ha + PSB	41.36	6.63	14.85	7.24
T_{10}	:	30 kg P_2O_5/ha + 20 kg S/ha + PSB	46.41	8.66	17.79	7.89
T_{11}	:	40 kg P_2O_5/ha + 20 kg S/ha + PSB	46.69	8.86	18.99	7.96
T_{12}	:	50 kg P_2O_5/ha + 20 kg S/ha + PSB	47.79	9.40	19.08	8.07
S.Em.±			1.54	0.32	0.69	0.19
C.D. (P = 0.05)			4.50	0.95	2.03	0.554
C.V. (%)			6.18	7.58	7.60	4.42

Table 2: Effect of phosphorus, sulphur and biofertilizer on 100 seed weight, seed yield and stover yield of kharif greengram

Treatments			100-seed weight (g)	Yield (kg/ha)	
				Seed	Stover
T_1	:	30 kg P_2O_5/ha	3.44	488	933
T_2	:	40 kg P_2O_5/ha	3.55	527	907
T_3	:	50 kg P_2O_5/ha	3.62	583	1042
T_4	:	30 kg P_2O_5/ha + 20 kg S/ha	4.02	627	1128
T_5	:	40 kg P_2O_5/ha + 20 kg S/ha	4.51	715	1124
T_6	:	50 kg P_2O_5/ha + 20 kg S/ha	4.56	738	1144
T_7	:	30 kg P_2O_5/ha + PSB	3.65	592	1012
T_8	:	40 kg P_2O_5/ha + PSB	3.66	598	1058
T_9	:	50 kg P_2O_5/ha + PSB	4.00	601	709
T_{10}	:	30 kg P_2O_5/ha + 20 kg S/ha + PSB	4.69	739	1294
T_{11}	:	40 kg P_2O_5/ha + 20 kg S/ha + PSB	4.74	743	1249
T_{12}	:	50 kg P_2O_5/ha + 20 kg S/ha + PSB	4.84	761	1317
S.Em.±			0.12	56	95
C.D. (P = 0.05)			0.35	164	278
C.V. (%)			5.10	15.12	15.24

Table 3: Effect of phosphorus, sulphur and biofertilizer on protein content in seed and protein yield of *kharif* greengram

Treatments			Protein content (%)	Protein yield (kg/ha)
T_1	:	30 kg P_2O_5/ha	19.6	101
T_2	:	40 kg P_2O_5/ha	19.8	104
T_3	:	50 kg P_2O_5/ha	20.3	118
T_4	:	30 kg P_2O_5/ha + 20 kg S/ha	20.5	145

T_5	:	40 kg P_2O_5/ha + 20 kg S/ha	20.5	148
T_6	:	50 kg P_2O_5/ha + 20 kg S/ha	20.8	153
T_7	:	30 kg P_2O_5/ha + PSB	20.3	120
T_8	:	40 kg P_2O_5/ha + PSB	20.4	122
T_9	:	50 kg P_2O_5/ha + PSB	20.4	123
T_{10}	:	30 kg P_2O_5/ha + 20 kg S/ha + PSB	21.9	162
T_{11}	:	40 kg P_2O_5/ha + 20 kg S/ha + PSB	21.9	163
T_{12}	:	50 kg P_2O_5/ha + 20 kg S/ha + PSB	22.2	169
S.Em.±			0.53	13.1
C.D. (P = 0.05)			NS	38.34
C.V. (%)			4.45	16.70

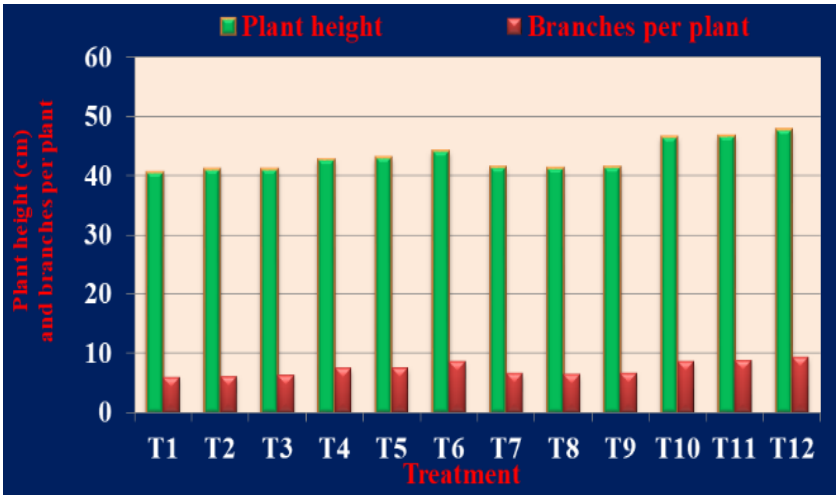

Fig 1: Plant height and branches per plant of *kharif* greengram as influenced by phosphorus, sulphur and biofertilizer

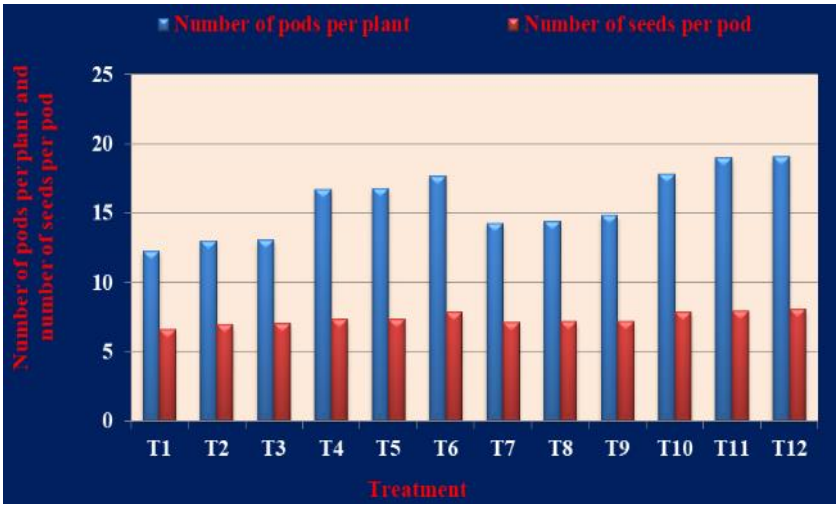

Fig 2: Number of pods per plant and number of seeds per pod of *kharif* greengram as influenced by phosphorus, sulphur and biofertilizer

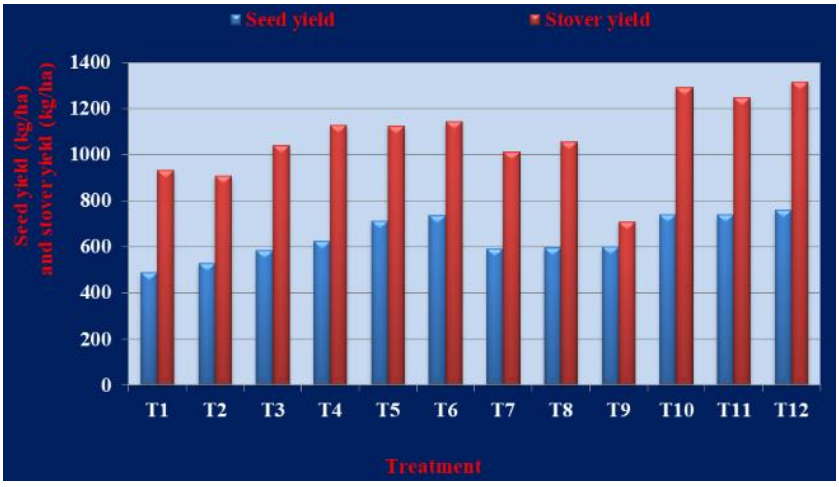

Fig 3: Seed and stover yield (kg/ha) of *kharif* greengram as influenced by phosphorus, sulphur and biofertilizer

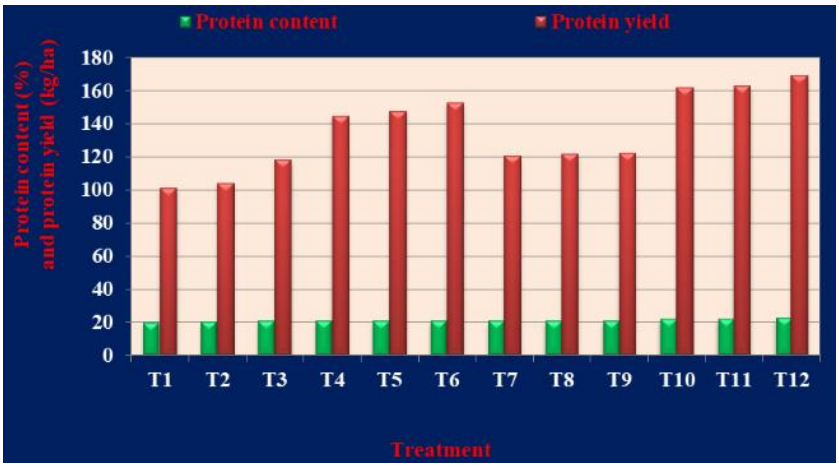

Fig 4: Protein content and protein yield of *kharif* greengram as influenced by phosphorus, sulphur and biofertilizer

Conclusion

In view of the results obtained from the present investigation, it could be concluded that for securing higher seed yield and net realization of greengram (cv. Gujarat Mungbean 4) raised on loamy sand under north Gujarat conditions, the crop should be fertilized with phosphorus @ 30 kg/ha, sulphur @ 20 kg/ha with PSB (Phosphorus solubilizing bacteria) liquid biofertilizer along with recommended dose of N @ 20 kg/ha.

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